

The Worldwide Challenge of Magnetic Fusion Energy Sciences



Presented by
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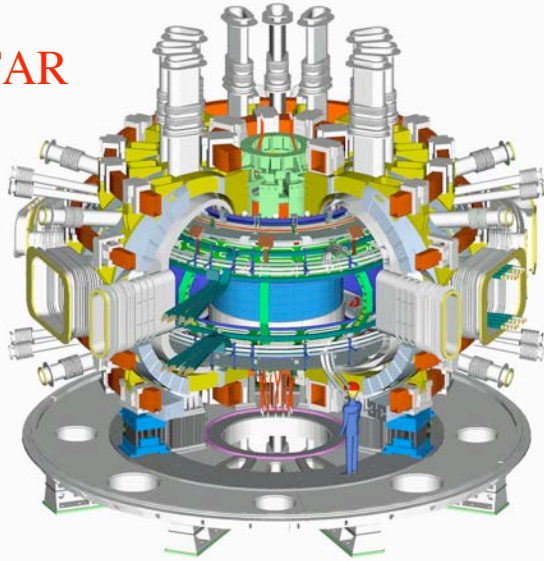
at
DOE National
Collaboratories Program
Meeting
August 10-12, 2004
Argonne, IL

PRESENTATION'S KEY POINTS

- The magnetic fusion energy science's experimental control room is a time critical environment
 - Demanding collaborative environment within the control room
- Future large experimental machines will not be in the U.S.
 - Collaboration critical for the U.S. fusion energy sciences to keep pace
- Collaborative control room has been prototyped by the SciDAC funded National Fusion Collaboratory Project
 - Testing at the 3 large U.S. tokamaks
- Opportunities are ripe and the computer science challenges significant to make the collaborative control room a reality
 - The NC 2004 report can be highlighted in the U.S “resume” as we seek to lead collaborative activities on next generation fusion devices

NEXT GENERATION EXPERIMENTS WILL NOT BE CONSTRUCTED IN THE UNITED STATES

KSTAR



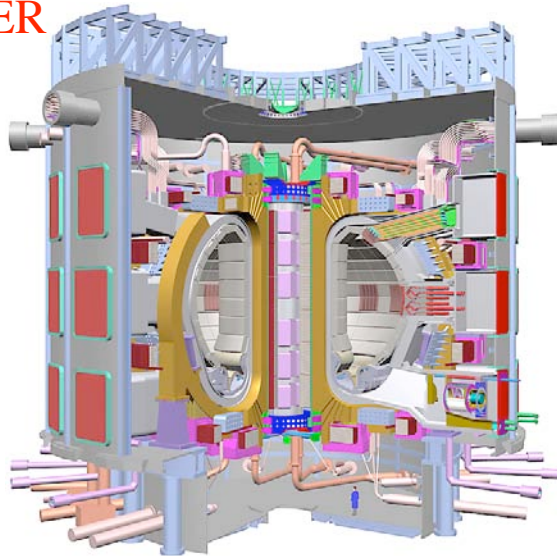
- KSTAR

- Korea, active U.S. participation

- ITER

- Located in France or Japan
- U.S. has rejoined

ITER



- Maximize U.S. benefit via collaboration

- Effective participation or be left behind

- Collaborative control room

- First prototypes today (FusionGrid)
- Defining needs

EXPERIMENTAL SCIENCES PLACES A LARGE PREMIUM ON RAPID DATA ANALYSIS IN NEAR-REAL-TIME

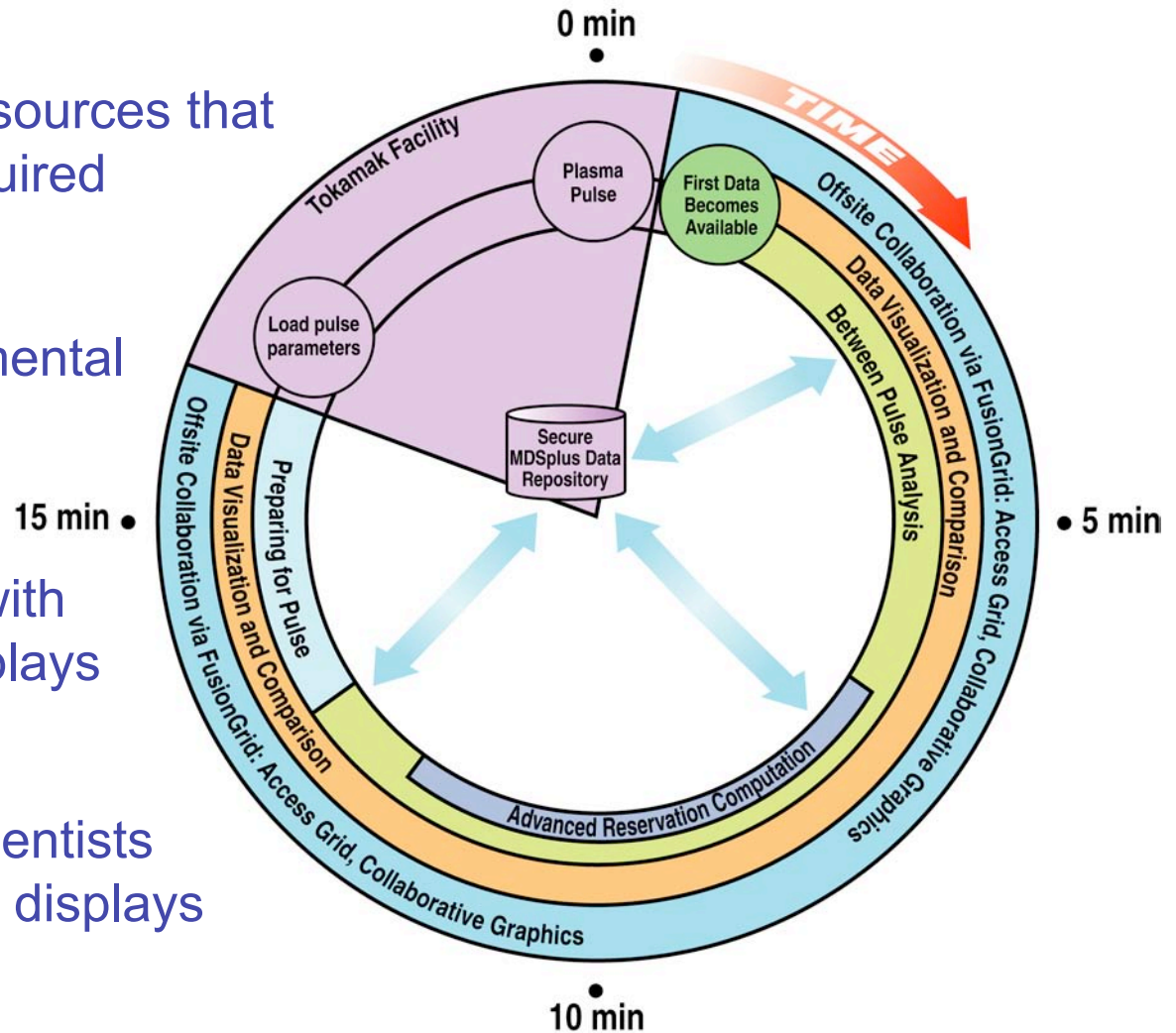


DIII-D Control Room

- Pulsed experiments
 - 10s duration plasma every ~30 minutes
- 20-40 people in control room
 - More from remote locations
- 10,000 separate measurements/plasma
 - kHz to MHZ sample rates
 - Between pulse analysis
- Not batch analysis and not a needle in a haystack problem
 - Rapid “real-time” analysis of many measurements
- More informed decisions result in better experiments
 - The collaborative or virtual control room

THE COLLABORATIVE CONTROL ROOM IS FUNDAMENTAL TO ADVANCING FUSION SCIENCE

- Secure computational resources that can be scheduled as required
- Rapidly compare experimental data to simulation results
- Share individual results with the group via shared displays
- Fully engaged remote scientists with audio, video, shared displays

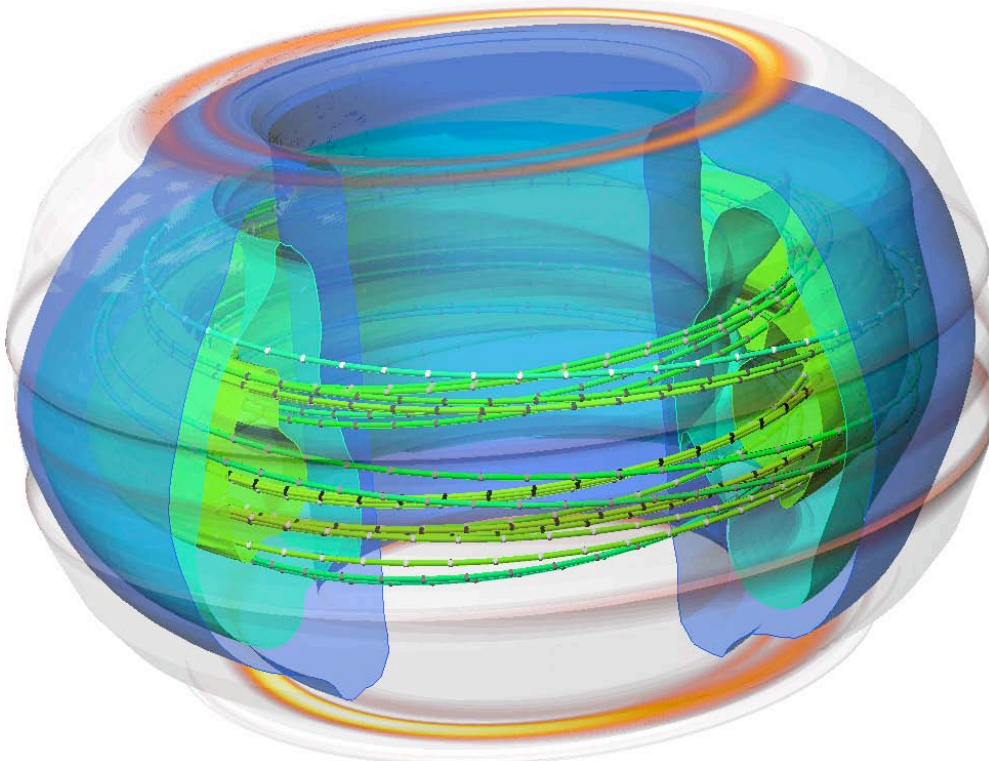


ADVANCED RESERVATION COMPUTATION FOR DATA ANALYSIS TO SUPPORT EXPERIMENTAL SCIENCE

- Long-term vision: Fusion code on supercomputer between pulses
 - The more information processed, disseminated, and digested between pulses the more valuable the experimental time
- Demanding requirements
 - Data management: both simulation and experimental data
 - Network QoS: scientists need to determine priorities
 - Security (Grid and Site): Authentication & Authorization
 - Visualization: digesting the large information inflow
 - CPU scheduling: again scientists decide
 - Faster CPUs & algorithms: more & more in a shorter time period

VISUALIZE COMPLEX SIMULATIONS WITH EXPERIMENTAL DATA FOR BETTER UNDERSTANDING

- Qualitative (situational awareness) to quantitative comparisons
- Examine pre-staged simulations, real-time simulations & experimental data



SciDAC CEMM NIMROD Simulation of a DIII-D Plasma

Collaborative real time
sharing is required

TILED DISPLAYS: COLLOCATED & REMOTE COLLABORATION

DIII-D Tokamak Control Room



NSTX Tokamak Control Room



- Enhanced collaboration within a large control room
 - “Publish” your analysis for the group to see and discuss
- Share and collaborate between tiled displays
 - Clone of tokamak control room (discussed for ITER)

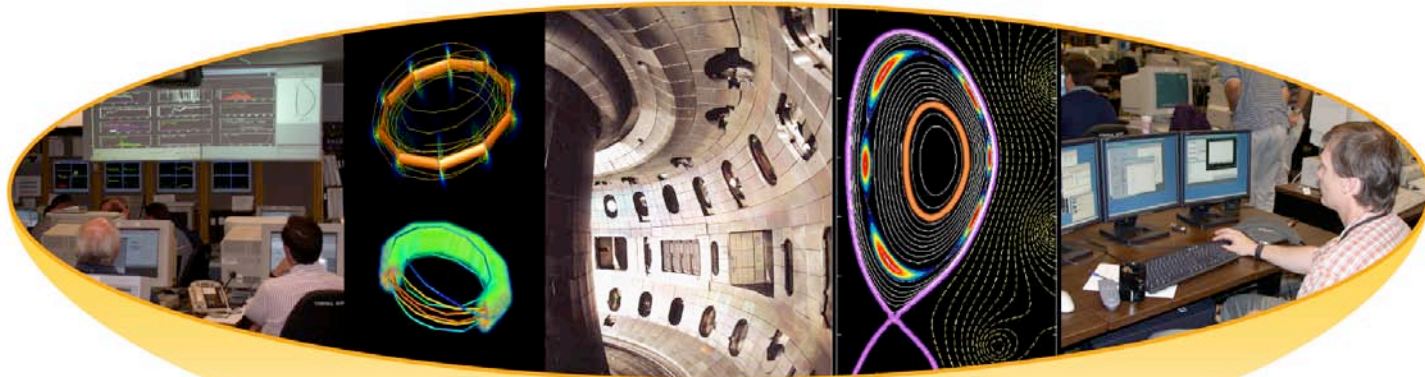
FULLY ENGAGE REMOTE SCIENTISTS: REAL TIME COMPLEX COMMUNICATION



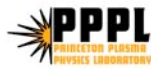
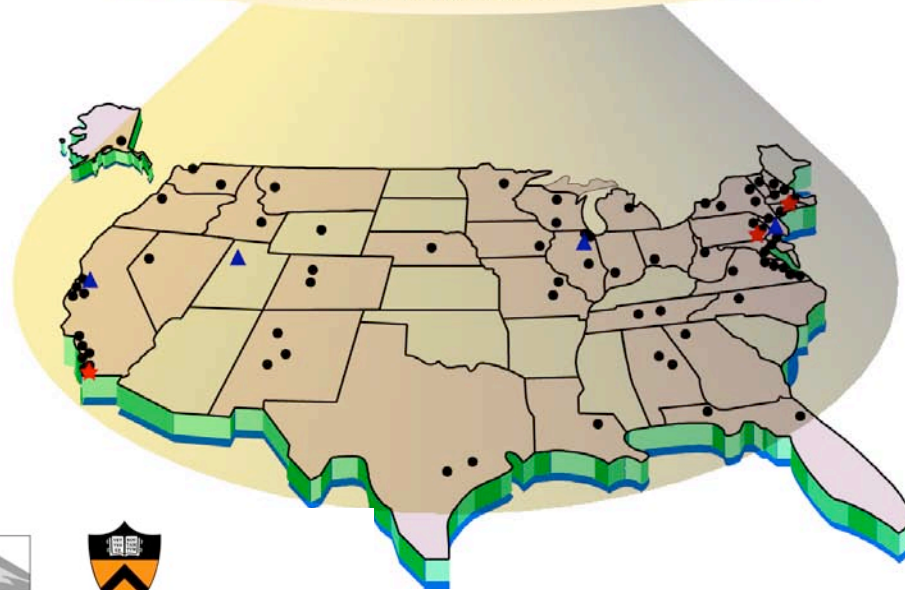
AG in DIII-D Tokamak Control Room - July 2003

- Multi-site participants
 - Rich collaborative environment
 - Includes application & data sharing
- Support a range of clients
 - Control room to professor & student
 - Keep the entry barrier low
- Same technology should be used for seminars, working meetings, code debugging, engineering design meetings, etc.

THE NATIONAL FUSION COLLABORATORY PROJECT: PROTOTYPING THE COLLABORATIVE CONTROL ROOM



National Fusion Collaboratory



SC03 DEMO: COLLABORATIVE CONTROL ROOM



- Fully interactive discussions utilizing AG
 - Includes shared applications
- Presence beyond AG communication
 - What one “sees and hears” in the control room

- Enhanced collaboration within the control room
 - Tiled displays and a shared X environment
- Advance reservation computation
 - Between pulse data analysis

REMOTE LEADERSHIP OF THE JET TOKAMAK IN ENGLAND FROM SAN DIEGO USING FUSIONGRID SERVICES

January 2004, San Diego



Ongoing usage between
U.S. and Europe

- First attempt for real science and it was successful
- Beginning to test with KSTAR (Korea)

SUBSTANTIAL CHALLENGES REMAIN TO MAKE THE COLLABORATIVE CONTROL ROOM A REALITY

- Grid & Site security (authentication & authorization) must get along
 - The largest barrier to wider collaborative activity
- Make ease of use a priority
 - Much more than providing functionality
 - Grid: Certificates, middleware installation & usage
 - ACE: Fully integrated audio, video, shared apps supporting many clients
- Deliver advanced reservation computation
 - Involves many aspects of computer science
- Scalable advanced visualization capabilities
 - Collaborative visualization of large 3D datasets
 - Implicit is a large dataset management issue
- Tiled Displays: Collocated & remote collaboration
 - Share to the group; Tiled wall sharing

CONCLUDING COMMENTS

- The requirements of the collaborative control room encompass in one instantiation the collaborative needs of fusion energy sciences
 - The most demanding since it is time critical and failure intolerant
- The opportunity exists for the U.S. to jointly lead a large collaborative activity for the worldwide magnetic fusion program
 - Maximize the benefit of future machines to the U.S. program
- The time scale for this opportunity is both near- and far-term
 - KSTAR on the 2-3 year time scale
 - ITER on the 10 year time scale
- Fusion scientists recognize the need for collaborative technology
 - An eager “driving application” willing to work together for a solution